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EDITED BY

REV. J. L. ZABRISKIE,

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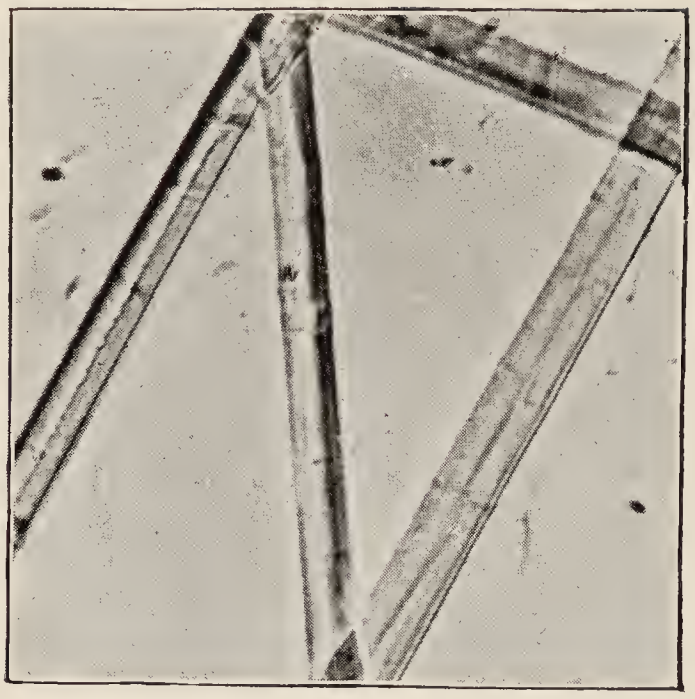

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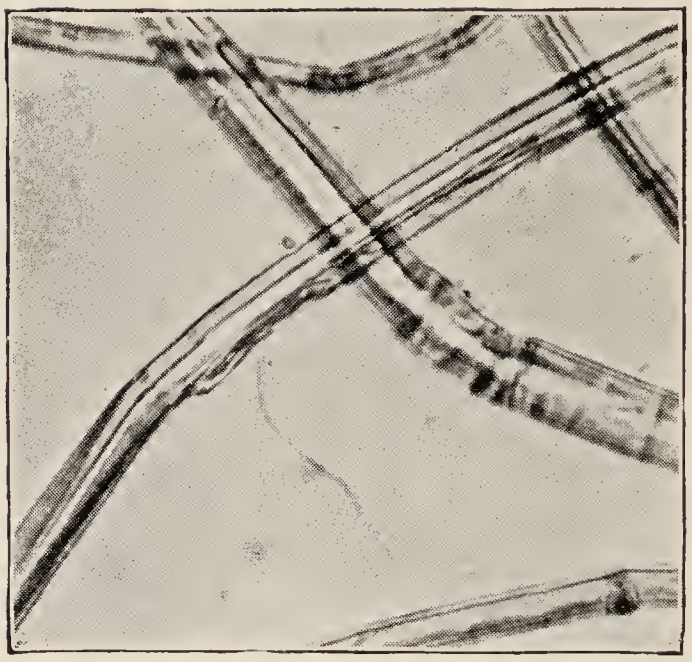

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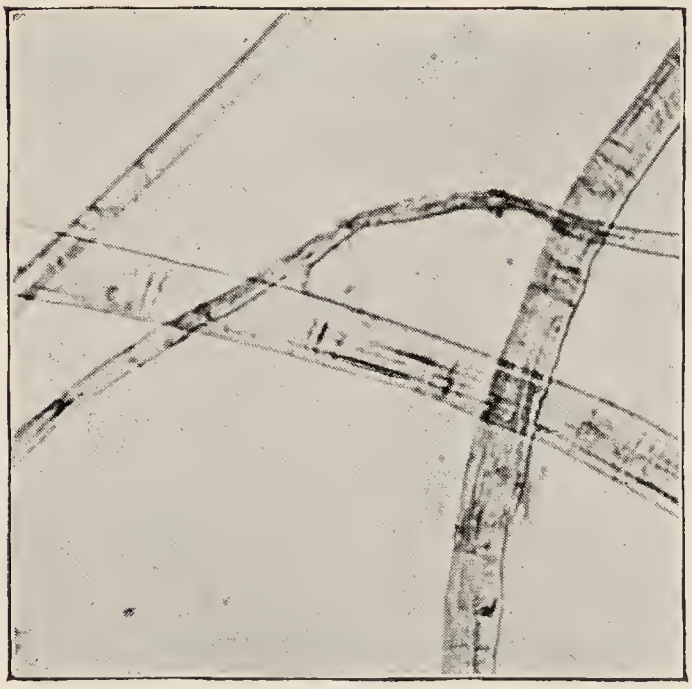

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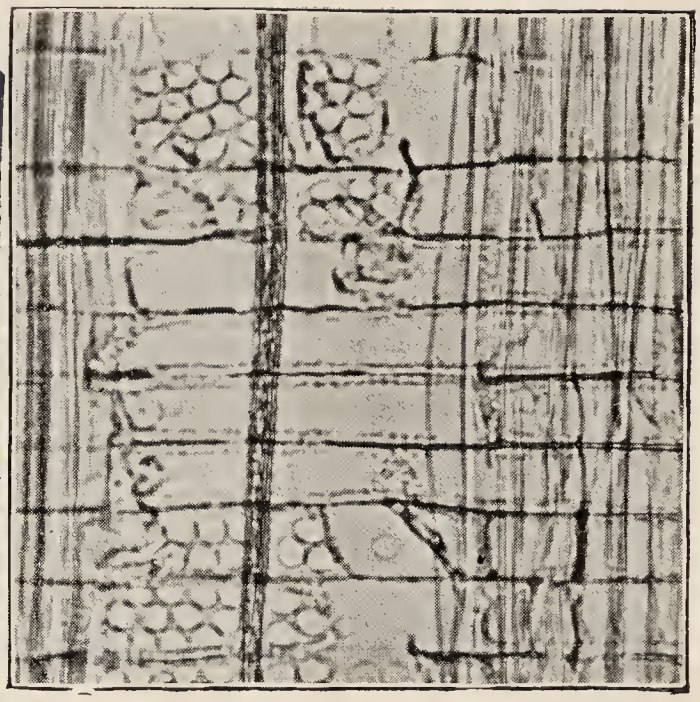

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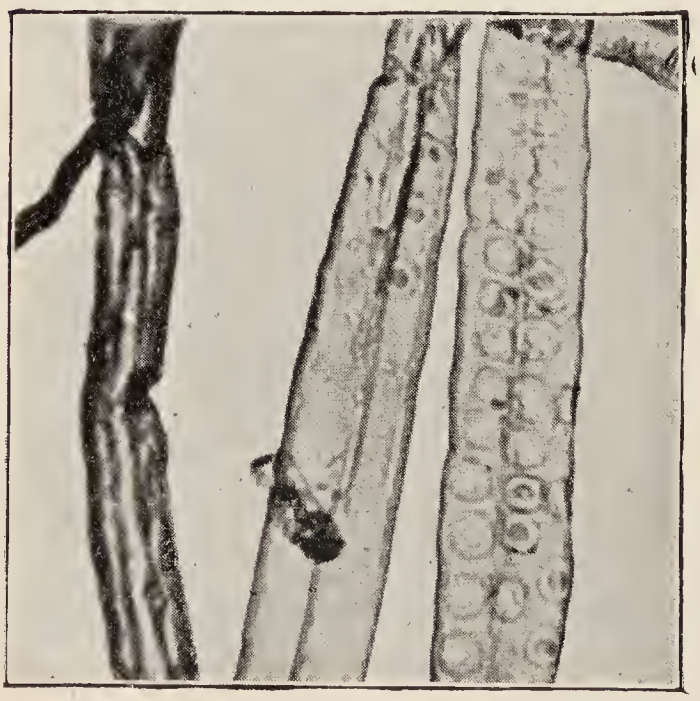

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JOURNAL

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VOL. X. APRIL, 1894. No. 2.

A MICROSCOPICAL AND CHEMICAL EXAMINATION OF THE ADMIXTURES AND ADULTERATIONS IN PAPERS USED FOR WRITING AND ENGRAVING.

ANNUAL ADDRESS BY THE PRESIDENT, CHARLES S. SHULTZ.

(*Delivered January 5th*, 1894.)

In my brief inaugural before the Society last January I spoke of the importance of the microscope as a means of detecting adulterations in food products, fabrics, etc. At that time I incidentally mentioned that a friend and myself had begun the examination of fine papers for a certain purpose.

Explanation of Plate 39.

FIG. 1.—Flax. From a fine example which was used in spinning at Flatbush, Long Island, in 1821.

FIG. 2.—Linen fibre. Ready for paper-making.

FIG. 3.—Linen paper. Extracted from a Michigan Central R. R. bond dated 1872.

FIG. 4.—Letter paper. Water-marked "Royal Irish Linen." Proves to be a mixture of some linen and much cotton.

FIG. 5.—Sea Island cotton. Shows twist in the fibres, but is not sufficiently enlarged to show any diagonal plaid structure.

FIG. 6.—The "Suspected Paper." Purported to be linen, but it proves to be a mixture of some linen, much cotton, some poplar-wood fibre, etc.

Explanation of Plate 40.

FIG. 7.—Longitudinal-radial section of the wood of *Populus monilifera* Ait., exhibiting the peculiar screen-like blocks of the medullary rays noticed in specimens of paper made from the pulp of this wood.

FIG. 8.—Poplar-wood fibre pulp. Made by "soda process."

FIG. 9.—Longitudinal-radial section of spruce wood.

FIG. 10.—Spruce-wood fibre, pulped. "Sulphite process."

FIG. 11.—Reputed "cottonseed-hull pulp." Proves to be fibre of coniferous wood.

All the figures are enlarged about 250 diameters.

The reason of this examination was that my friend, Dr. T. B. Stillman, professor of analytical and applied chemistry at the Stevens Institute of Technology, in Hoboken, received from a firm of engravers a specimen of paper which had been offered to them as "linen paper," suitable for some of their purposes. They wished Dr. Stillman to make a hasty determination of the paper and report as to its constituents. He undertook to do this by chemical means, but, on account of a similar reaction by nearly all vegetable fibres composed of cellulose, his analysis proved unsatisfactory to himself. He looked over many written authorities upon the investigation and manufacture of fine paper, and concluded that chemistry alone would not solve his difficulty, and that, if the constituents were to be fully determined, the microscope must be brought in to complete the analysis.

He asked me to assist him in the case, as he was not an expert in the handling of the microscope. I, who had never undertaken the systematic examination of paper, however, consented to aid him in the analysis of this, which we shall call our "suspected paper." Like many microscopists, I had casually examined fibres of linen, cotton, silk, etc., and had in a general way run through sections of various woods; but when at this time I undertook to examine various papers and paper pulps, I, for want of experience, found myself entirely "at sea." This "suspected paper" seemed to more particularly puzzle us. It had in its appearance much of the straight-fibred characteristics of linen, but it also showed cotton, and in the tangled mass upon the slide other matter cropped out with which I was unacquainted. In short, after making numerous examinations and comparisons with several woods and a variety of papers and pulps, we arrived at the conclusion that this "suspected paper" was composed of a little linen, much cotton, and some wood, mainly poplar; it having probably been largely made up of old or repulped paper, heavily sized and nicely finished. I have but a small piece of this paper here, which I offer for examination.

Up to this period I was not aware of the use of so large an amount and variety of woods in the manufacture of writing and other of the finer papers, supposing that merely newspapers, books, and printers' common stock were made from wood pulps. Much less did I know of the various misrepresentations of the

paper trade until later, when, to my surprise, we found high-class paper manufacturers, both in this country and in Great Britain, who water-mark their products as "Pure linen stock," "Royal Irish linen," "Pure parchment, one hundred per cent chemical fibre," and other high-sounding names, employed admixtures of cotton and various woods, more particularly spruce, some varieties of poplar, fir, white pine, etc., as may be seen by slides Nos. 4–6 and several which are not numbered (Plate 39, Figs. 4 and 6).

Having made this discovery, and now being upon our guard, in order to ascertain what was published upon this topic we looked up some of the literature upon the proper means of detecting admixtures in paper.

We could find but little that was very definite or of much value in the English or American works, but found much in German concerning investigations in progress, although these investigations were usually conducted by intricate and tedious processes.

The work in this line performed and in progress in the German Kais. Königl. Versuchstation at Berlin appears to be the most valuable that came to our notice. Of these I have made a few extracts, which I will give further on if time permits.

The various modern processes in pulping a variety of the vegetable fibres, and the admirable texture and finish given to many of the finer manufactured papers, make it very difficult to get a qualitative, much more a proper quantitative, analysis of these products.

It might be well at this stage to submit a brief outline of the general manner in which paper is manufactured, in order to have you comprehend why it is so difficult to distinguish, in this progressive age, the superior all-linen stock from the cheaper mixtures of cotton, woods, etc. At the head of the list stands the ancient papyrus, of which the first was probably made in Egypt from a species of reed belonging to the family of Cyperaceæ, or sedges. A fine paper was also early made from the inner layers of the cuticle of the mulberry and other trees, laid side by side, and a second layer being placed at right angles; all were wet ted, pressed together and dried in the sun, beaten smooth with a mallet, and polished with a piece of ivory or shell.

The Aztecs made a kind of paper from the leaves of the maguey plant, which plant is still grown extensively in portions of Mexico; but the modern Mexican prefers to brew from this plant his "pulque," the national beverage, and his paper is now made from other substances, much like our own.

To the Chinese, however, has been attributed the manufacture of the first paper made upon modern principles, viz., that of pulping vegetable fibres.

My attention was called to a work in German and published in 1887, entitled "Die mikroskopische Untersuchung des Papiers mit besonderer Berichsichtung der ältesten orientalischen und europäischen Papiere," by Dr. Julius Wiesner, professor of botany and vegetable physiology in the University of Vienna.

This book, a quarto of eighty-two pages, is mainly intended as a history of paper-making, and gives the constituents of writing papers manufactured from the ninth to the nineteenth century, showing the earlier papers to consist of more or less wool mixed with hemp and linen; and later, as made in the eleventh to the fifteenth century, a mixture of wool, linen or hemp, and cotton, heavily sized with glue or starch, prevailed; and in the fifteenth century the use of wool in paper ceased.

After this, according to this author, the European papers were made of linen and small quantities of cotton combined, but in the early part of the present century cotton was used in larger quantities as an adulterant of linen and hemp papers. Later on cotton was used as the sole ingredient of the cheaper writing papers.

This author gives the names of many letters and public documents from which paper has been taken and examined by himself and others, working together on these historical investigations at this time. He also mentions the labors of Briquet and Caruel in their microscopical researches on papers used from the eleventh to the fourteenth century inclusive.

Among the older papers examined by Dr. Wiesner there are some found in the tombs of Egypt; others from Arabia, Damascus, and other portions of Syria; also many important documents in Italy and of various parts of Europe from one thousand years ago to the present century. In each case he states from what materials these papers are manufactured, gives the title of the

writing or document and the date thereof, making a curious and interesting history.

The usual processes of paper-making are well known, but I will mention enough of them to indicate why it becomes so difficult to detect adulterations and admixtures therein, either chemically or microscopically. The chief reason why we cannot separate the component substances of paper microscopically, is because the linen or cotton rags, or both of these mixed, are placed in the "beating machines," equipped with long knives and flail-like arms, which tear up and beat out all traces of their original textile nature. With protracted maceration in strong alkalies the mass is reduced to a jelly-like pulp. This mass is retained in hot water for many hours, bleached with chloride of lime, sized with gelatin, or resin soap, and alum dissolved in soda. China clay is sometimes added to improve its weight and surface rather than its quality. One would think that these tearing, macerating, and chemical pulping processes would be quite sufficient to obliterate all traces of the original fibres; but when to this is added old paper to be reworked, then the difficulty of optically separating the original fibres becomes extremely aggravated, so that while one knows upon microscopical examination that he has not pure linen paper before him, he nevertheless finds himself embarrassed in determining what he sees in the broken-up and tangled mixture, however carefully he may arrange it upon the slide. You may demonstrate this for yourselves by looking at slide No. 6, this being our "suspected paper" which was offered for linen (Plate 39, Fig. 6).

When, however, a percentage of wood pulp ready for paper-making is mixed with linen, or linen and cotton pulp, and especially if the wood is of the coniferous order, such as spruce or white pine, etc., then the woody admixture is quite easily discerned, although it may have been cut to pieces and pulped.

In slide No. 8 you will see a fair example of a spruce-pulp paper by one of the chemical reductions, known as the "soda process" (Plate 40, Fig. 8).

Now as to the modes of manufacturing wood pulps for paper-making.

There are two general methods, one known as the "mechanical" or "ground wood," and the other as the "chemical" pulp

process. These are again subdivided into "sulphite," "soda pulps," etc. By the "mechanical" or ground-wood method any suitable wood is taken, usually, on account of cheapness, the edgings, slabs from sawmills, small cordwood, and other waste stock. In the "Voelter" process, which is German, the defiberer, or mill, consists of a coarse cylindrical stone revolving rapidly, against which the pieces of wood are held by springs. The water which flows through assists in reducing the fibre so finely that the subsequent chemical treatment is simple. The "mechanical" processes, however, break up the fibres into short particles, thereby reducing the strength of the pulp and permitting less of this pulp to be mixed with linen or cotton, on account of the consequently greater friability of this woody matter.

Among the various "chemical" wood-pulp processes is one in which the wood is not disintegrated, as by the "mechanical" or ground-wood methods, but convenient-sized pieces are placed in a steam-tight vessel and boiled with about twenty per cent of strong caustic soda under a pressure of ten to fourteen atmospheres. In another, by the popular "Mitscherlich" patent method, bisulphite of lime is used instead of soda; and the best wood pulps are prepared by the several "sulphite" processes.

I show you here several examples of these methods in sheets of dried pulp, and finished papers, Nos. 12 to 17, with the color action of various reagents upon them, which were treated by Prof. Stillman, and which I will explain after I shall have finished this paper. The mounted slides of the corresponding numbers are on the stands for your inspection.

Now, as if the several methods of paper-making, as briefly described, were not sufficiently destructive, there is still another curious mode—that is, the converting of cane wood into pulp. By this, the "Lyman" process, the disintegrated cane is placed in strong iron cylinders, called "guns"; these are about twenty-two feet long and twelve inches internal diameter, and are laid on heavy frames. The heads are fastened on both ends, and steam is admitted until a pressure of one hundred and eighty pounds to the square inch is reached. This pressure is maintained for about twelve minutes, when, by pulling a trigger, the covers are suddenly released, and the steam, propelling the mass of disintegrated wood before it, rushes out with an explosion equal to that of a large

cannon and may be heard many miles. The charges from these "guns" are fired against an iron target about thirty feet distant, leaving a spongy mass which is then converted by chemical treatment into paper. Besides the mangling of paper stock by the various pulp-making methods, there are still the several processes of finishing, such as bleaching, sizing, and moulding the pulp by means of wire gratings, upon which the setting or hardening pulp rests; a portion of these screens, with figures or names placed in them by means of thinner wires, producing the "water-markings" commonly seen on writing papers.

In addition to these we have the calendering, glazing, filling, and numerous other finishing processes, with which I will not further weary you.

Having now seen these several constituents of paper variously torn, cut, beaten, mangled, shot out of "guns," ground up, dissolved by chemical means, and many of these substances completely transformed from their original condition and the appearances with which we are familiar, how are we to determine what they are? When we consider the great variety of materials used in the manufacture of paper, and yet know that all of them consist of cellulose, which gives a similar reaction chemically, we find that the chemist is debarred from positively identifying any admixture of pulps or finished paper, although he can detect "mechanical" wood pulp unmixed, as we shall see later, by the color demonstrations on the papers, as heretofore mentioned and here exhibited; but beyond this stage chemical tests become unreliable.

We see, therefore, why almost the entire determination of admixtures in paper rests with the microscopist.

It is easy to recognize under the microscope the ordinary materials from which paper is manufactured, such as linen, cotton, various woods cut in thin sections, etc., when each of these substances is in its natural condition and properly mounted for microscopical observation.

Here are displayed before you under magnification not only preparations of the actual materials—flax, cotton, etc.—but also a number of photomicrographs of the same preparations distinctly exhibiting the details (Plate 39, Figs. 1, 2, 5; Plate 40, Figs. 7, 9). In addition to these examples of the simple fibres

you will also see here illustrated in the same manner the more intricate specimens of various pulps for paper-making, composed of linen, cotton, mechanical and chemical wood processes, besides one slide purporting to be "cottonseed-hull pulp," but which instead proves to be of coniferous wood, as you will readily see from its well-known characteristics (Plate 40, Fig. 11).

Let us go a little further and examine the finished papers, portions of which we have here upon our slides. Previous to mounting these Dr. Stillman prepared them for the purpose of eliminating the sizing, rosin, filling, etc., with which they were finished. This is accomplished in this manner: Cut the finished paper in small pieces, and place them in a beaker, adding a sufficient quantity of a solution of caustic soda (caustic soda one part, water thirty parts). Digest the paper just below the boiling point for about fifteen minutes. Pour off the liquid and replace with double the quantity of distilled water. Pour off this water and wash once again in the same manner. Add the same quantity of a solution composed of fifteen parts of distilled water to one of hydrochloric acid. Digest ten minutes with a gentle heat. Pour off this liquid and wash in warm distilled water about three times, then dry the paper for mounting in glycerin or balsam. In order to get some contrast in the fibres for photographing, stain them lightly with hæmatoxylin.

As an example of pure linen paper shown here, and which is becoming somewhat scarce in the market, I have extracted a specimen from a railroad bond now twenty-two years old (Plate 39, Fig. 3). We have here also a specimen of a sheet which is water-marked "Royal Irish Linen," a letter paper sold at a good price. Inspect this under a microscope, and you will have no difficulty in finding a fair proportion of cotton mixed therein (Plate 39, Fig. 4). In the slide (No. 6) already mentioned as from our "suspected paper" you will see scattered through it but little linen, and will see some woody indications, with plenty of cotton; but, on account of the tearing-up, pulping, and repulping process it has undergone, it will be found very difficult to eliminate the various disintegrated fibres therein contained. The sheet from which the specimen on slide No. 13 was taken is called by the manufacturer "parchment paper." I regret to have mislaid this sheet. This was a strong, nicely glazed, and

highly finished paper. From its name and general appearance one would think it might be pure linen paper, but you will find nothing but cotton in the specimen under the microscope. We have not known any attempt of the manufacturer to palm off papers made wholly of wood for linen, but the several kinds of wood pulps are frequently mixed with linen and cotton-rag pulps, and when finished are sold for high-class paper, while the cheaper grades are made almost entirely from wood pulps.

Both in the "mechanical" and "chemical" wood paper systems the woody markings may be distinguished by the aid of the microscope, and more particularly the coniferous fragments (Plate 40, Figs. 10, 11).

Poplar-wood fibre, when torn up, somewhat resembles cotton, but there is at least one distinguishing feature, even among the disintegrated "mechanical" pulps—that is, the tangential fragments have among them particles bearing a grate- or screen-like appearance; some of these evidences may be seen in slide No. 7, a section of the wood of *Populus monilifera* (Plate 40, Fig. 7). Slide No. 16, being paper of the Singerly Pulp and Paper Co., also exhibits this peculiar feature, indicating poplar wood "ground" up by the "mechanical" process. Slide No. 17 is of Woolworth & Graham's "ground wood pulp," which also shows a little of the poplar character, but the mass is so full of short fibre as to be practically unrecognizable, and is only fit for printers' low-grade work. The chemical tests, however, show plainly by their peculiar colors that this is "ground wood."

We have here a sheet of dried pulp from Norway, called "Eker," which is shown by the microscope to be composed of spruce wood, and, as you will see by its bright-red color in its chemical reaction, when I slightly touch it with para-phenylen-diamine hydrochlorate, is proved to be "mechanical fibre."

I will not go into further detail regarding the varieties of paper intended for the higher classes of work. It is patent that there is much yet to be learned about the methods of detecting mixtures in paper, even for the ordinary qualitative tests; and as for quantitative analysis, we have found no better method than those adopted at the German testing station at Berlin, where an eye-piece micrometer, ruled in squares, is used to count, as best may be, the several fibres or parts of fibres of each admixture con-

tained in any square or number of squares, and by this means to arrive at the average proportions of each kind of material contained in the mass.

A glance through the microscope at some of these paper compositions will, I think, satisfy you that, even after making many measurements and taking the average of them, the final determination will be far from correct, on account of the thoroughly intermingled condition of the various substances; the differences in the dimensions of the divers kinds and shapes of the fibres; the broken portions of many of these; as well as the impossibility of discriminating between the ingredients in their disintegrated state. For the reasons given I have not, up to this time, attempted a quantitative determination in mixed or adulterated papers. For similar reasons no fixed rule can be laid down for optically separating the constituents in the finer papers, except by long and diligent practice with the microscope, thereby training the observer's eye and mind for the discrimination necessary in detecting such matter as one finally becomes familiar with by certain details he has previously recognized, and by comparison with the elements which form the component parts of the usual admixtures or adulterations named in the subject of this evening.

I am thankful to Prof. Stillman for bringing this matter to my attention originally; for the valuable aid he has given me in his chemical preparations; for collecting examples of paper stock; and in pointing out much of the bibliography bearing upon this class of investigation. You are also indebted to him for the color reactions which he has so well shown, by means of the numerous examples of pulps and paper treated by him which I have laid before you, and which I will briefly explain when I apply some of these reagents to show you their rapid action on some papers.[1]

We are under obligations to Dr. E. G. Love for the photo-micrographic illustrations of many of the slides upon the tables, which enable us to more readily conceive the appearances of the

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[1] On account of the chemical investigations by Prof. T. B. Stillman, now in progress and relating to papers and their constituents, I do not mention at this time any of the other chemical reagents shown here, but hope that he will in the near future give for publication, in a chemical or other technical journal, a more complete means of chemical identification than has hitherto been known.

several original substances here shown, and the results when these are made into pulp and paper, as I have already described.[1]

I regret that I am unable to throw more light upon what we have discovered to be an intricate and vexatious subject; but if no further advantage shall be attained from our earnest efforts at this time, I hope, at least, that other members will be induced to take up not only the further investigation of paper admixtures, but also the analysis of many of the familiar products manufactured and in common use, with a view of making known to the world what adulterations they severally contain.

Moreover, I have chosen a utilitarian theme on this occasion whereby the microscope is applied to the economic arts; may I be pardoned, therefore, for the lack of truly scientific work which might be expected in an annual address before such an association as ours? If no other benefit shall result therefrom, we as microscopists, when engaged in kindred lines of research where science is applied to the practical arts, may perhaps disprove the imputation that we can claim no independent position in either the arts or sciences.

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[1] Of the numerous photomicrographs made by Dr. Love, we have had portions, two inches square, cut from eleven of them, and reproduced in half-tone by the photo-engraving process, and inserted in this publication in two plates.

THE COMPARATIVE ANATOMY OF THE VERTEBRATE SKIN.

BY GEORGE WILLIAM KOSMAK.

(*Read January 19th*, 1894.)

I. Introduction.

The subject to which I ask your attention this evening presents to both biologist and microscopist a varied and fascinating line of work in original research and investigation. In its morphology and physiology many points are still doubtful and obscure, awaiting the biologist's explanation and elucidation; while to the working microscopist there is held forth an equal opportunity in a field where little satisfactory work has yet been done—*e.g.*, in the technique and new methods of sectioning and staining.

The study of the skin, anatomically and physiologically, is a subject vast and extensive, with an accompanying literature equally so. The latter, however, consists of a mass of detail, much of which is unimportant. The beginner must wade through

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Explanation of Plate 41.

FIG. 1.—Diagram of Fish Skin. Transverse section, illustrating general structure. (After *Wiedersheim.*) S C, striated cuticular border of epidermis; A, slime cells; E, epidermis; D, derma; K, goblet cell; L, granular cells of *Petromyzon;* B, blood vessels; V, vertical connective-tissue bundles; H, horizontal connective-tissue bundles.

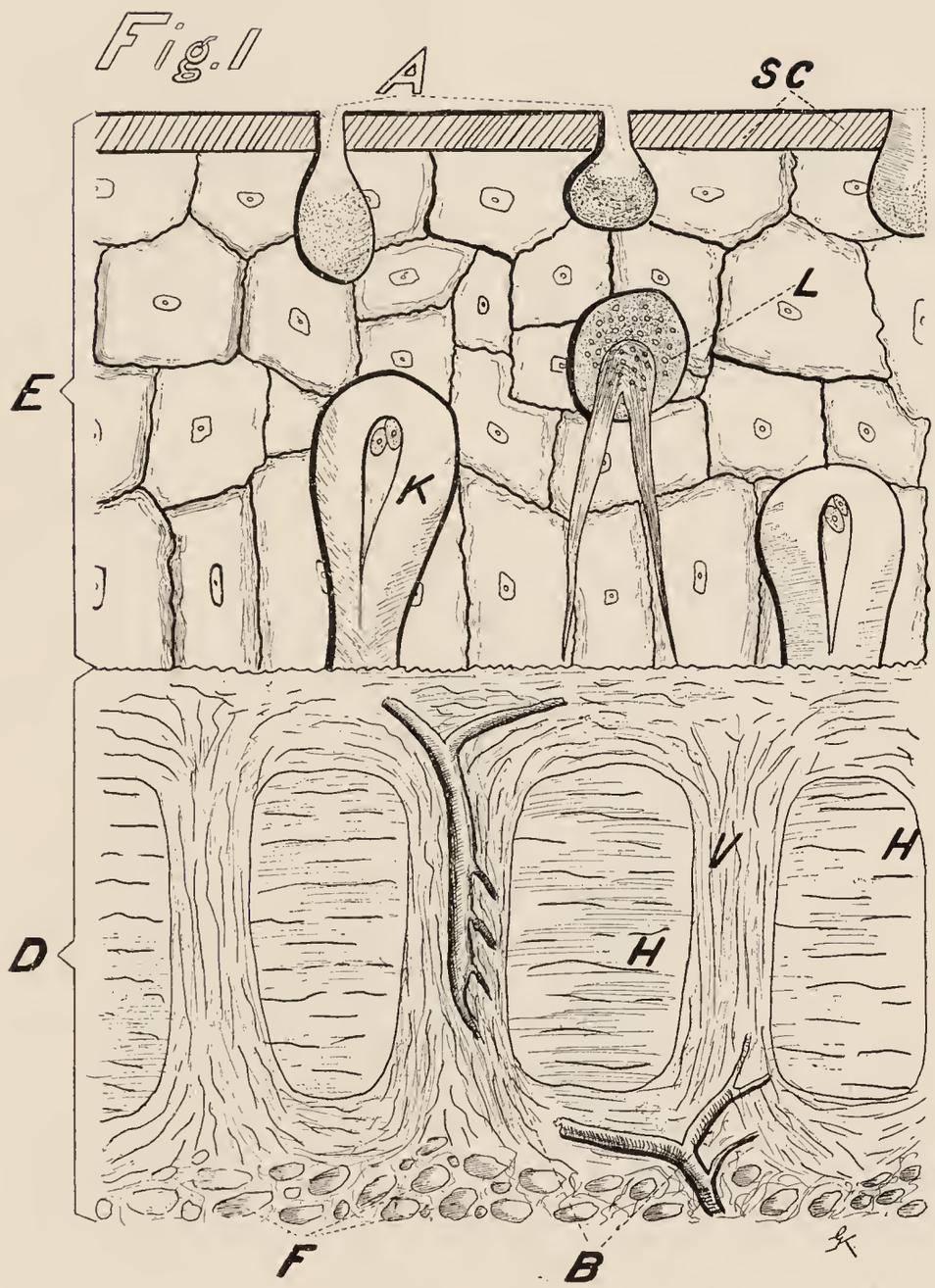
Explanation of Plate 42.

FIG. 2.—(*a*) Diagrammatic cross-section of skin of larval Salamander; (*b*) ditto, of adult form. (After *Wiedersheim.*) E, epidermis; D, dermis; S C, striated cuticular border of E; C, stratum corneum; M, stratum Malpighii; P, pigment; O, subcutaneous layers of muscle; B, blood vessels; N, epithelium of glands; X, Y, integumentary glands; T, muscles of glands.

Explanation of Plate 43.

FIG. 3.—Feather Development. Diagrammatic. (After *Studer.*) *a*, *b*, *c*, *d*, *e*, *f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, F′, feather germ; P, pulp; Q, quill; B, barbs; B′, barbules. *c* is a cross-section of the feather germ in *b*, showing the ridges of Malpighian cells covered by the horny layer of epidermis.

FIG. 4.—Hair Development. Diagrammatic. *a*, *b*, *c*, *d*, *e*, *f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, hair follicle; B, blood vessels; K, hair knob; G, sebaceous gland; P, hair papilla—in *e* and *f* are indicated two stages in its formation; in *f* it has become vascular.



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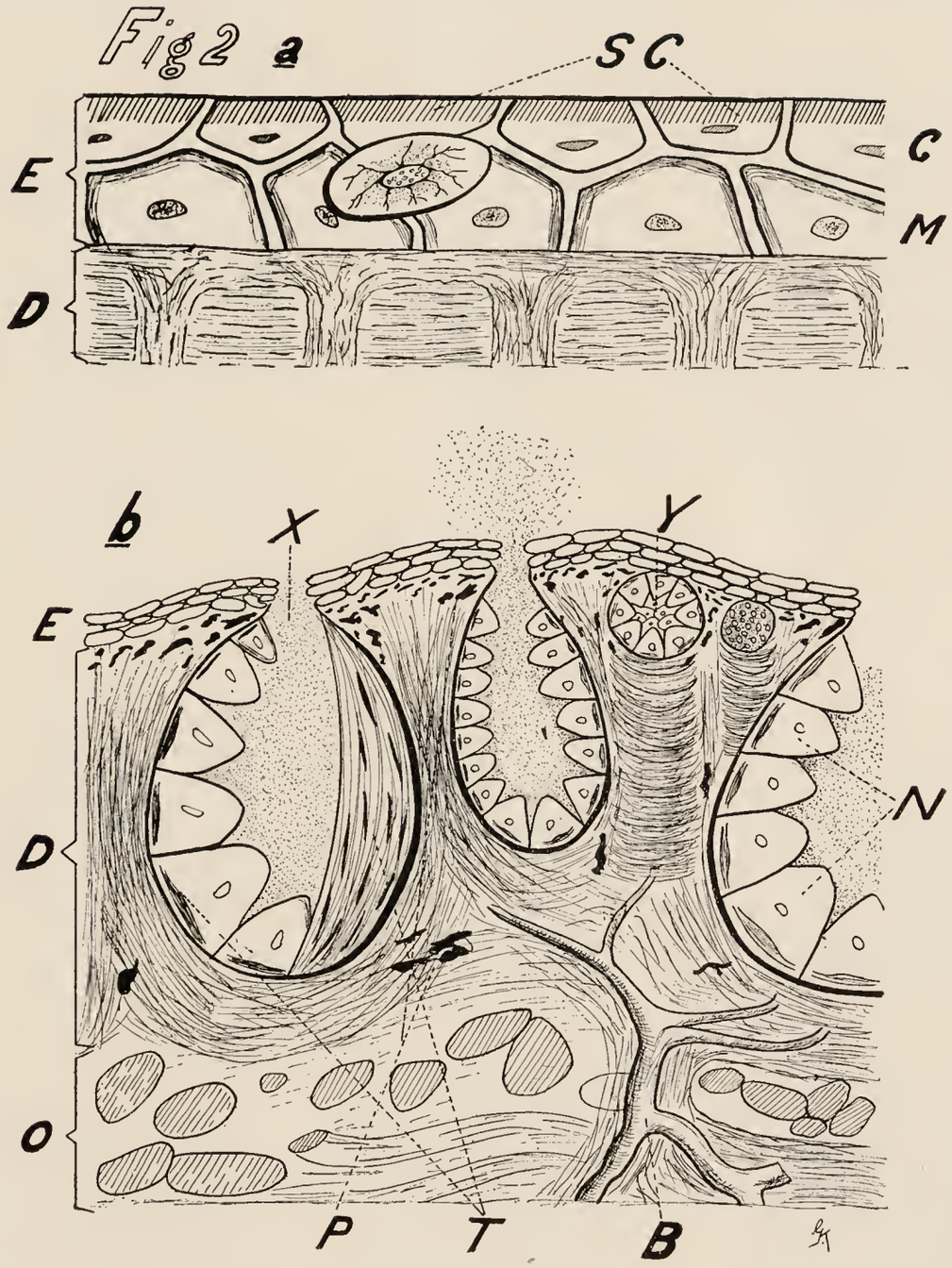

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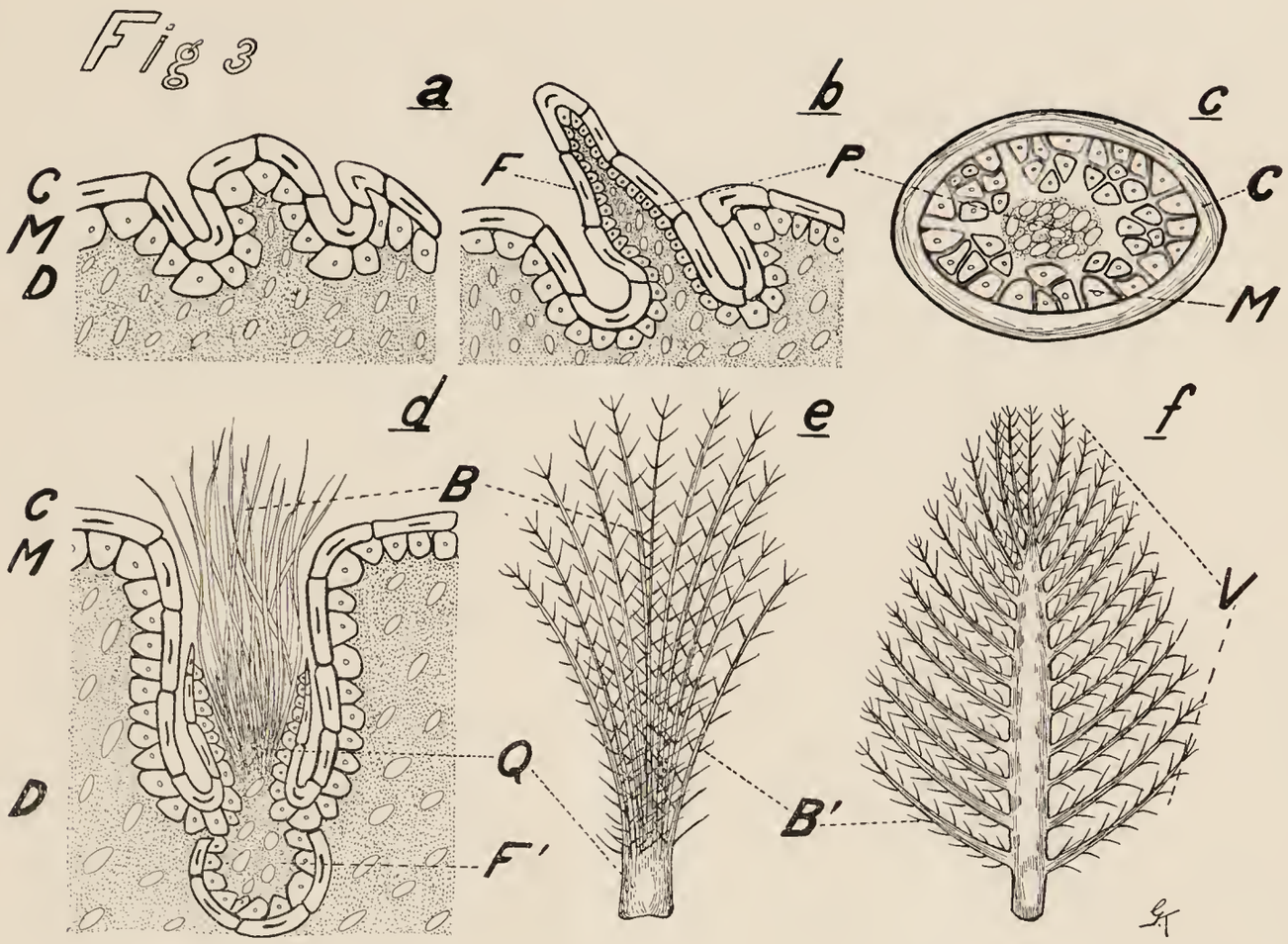

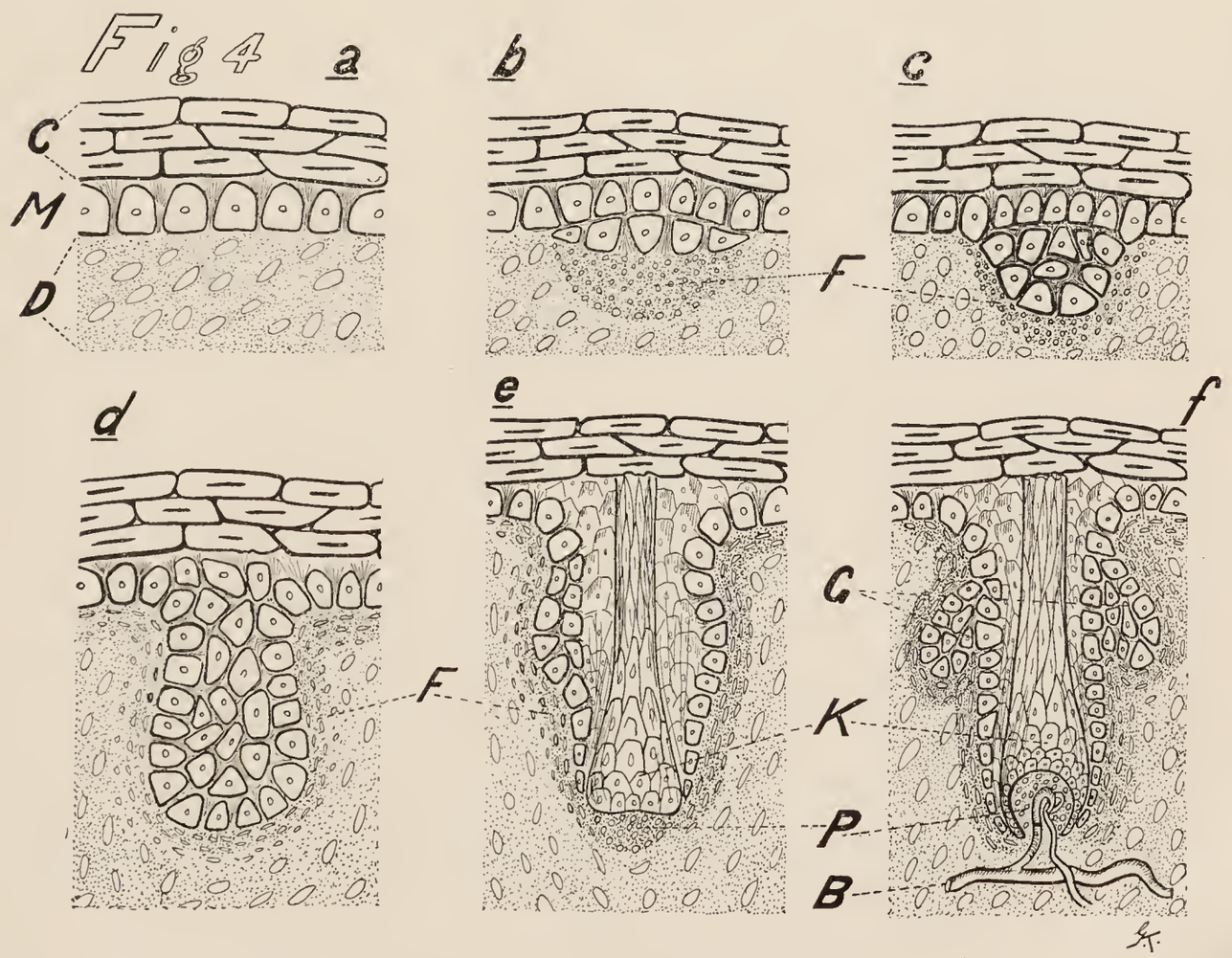

VERTEBRATE SKIN.

it all, as there is no general work on the subject that I have yet found—no manual which treats of the anatomy and physiology of the skin in a comparative sense, with a section devoted to microscopical methods. The need for such a work is evident.

Owing to this magnitude I can only speak of generalities. I will first say a few words of the skin in general ; then take up the several types of vertebrates, and speak of their most characteristic structures as derived from the skin ; and finally make brief mention of the theories of homologies and correlations that have been noted in the higher types.

II. The Skin in General.

The vertebrate skin, as derived from the embryo, consists of two layers, a superficial ectodermal and a deeper mesodermal layer. The former is called the *epidermis* (scarf-skin), the latter the *dermis* (corium or cutis). The skin, like a mucous membrane, consists of an epithelium resting on a connective-tissue basis, the epithelium forming the *epidermis* made up of a few or many layers of cells. The surface of the *dermis* is thrown up into a number of elevations, called papillæ, which differ in form, size, and complexity in different regions of the body and with the position in the animal scale. The epidermal or outer layer does not follow this papillary contour of the dermis, and when the two layers are carefully pulled apart and examined (*e.g.*, in the human skin) the papillæ appear to plunge into and be covered by the more even epidermis, although the outer surface is well marked by ridges and furrows, such as we can plainly see in the palm of the hand. These papillæ are the end organs of that most important sense, *touch*, and in the lower forms may also function as other sense organs, which will be spoken of later on.

The outer or epidermic layers always consist of cells only, while the derma is made up also of connective-tissue fibres, as well as of elastic and contractile elements. In the epidermis two layers can always be distinguished—an outer, composed of horny cells, and therefore called the *stratum corneum ;* and an inner, made up of soft protoplasmic cells, the *stratum Malpighii.* The latter really serves as a matrix for the regeneration of the outer, horny layer, the superficial part of which is continually scaling

off. Nerves, glands, pigment cells, bony structures, and blood vessels occur principally in the dermis. So-called epidermic structures, such as skin glands, hairs, feathers, nails, hoofs, claws, bristles, etc., are formed from the epidermis or outer layer. These will be treated of in those types in which they are most characteristic, and we can then also see how environment, both natural and artificial, has brought about many changes both in their form and function. This need not appear strange or wonderful when we consider how accessible the outer surface of the skin is to external modifying influences. Before beginning with our types of animal life and illustrating the modifications that occur, the two primary divisions of the skin must be borne in mind—an outer layer, protective, and an inner layer, nutritive in function.

A few words in regard to the general physiology. Broadly speaking, the waste products of the body are *urea*, *carbon dioxide*, *water*, and various *salts*. These leave the body by one or other of three main channels : the *lungs*, the *kidneys*, or the *skin*. The lungs discharge most of the carbon dioxide and some water ; the kidneys, the urea and allied bodies ; the skin, a small amount of the salts and nearly all the water. The skin is therefore the great evaporating agent, and the discharge of waste products by this channel we know as perspiration or sweat.

It has been proven that death would ensue in an animal in which this cutaneous evaporation was prevented by covering its body with an impermeable varnish which retained the sweat in the glands, which thus acted as a poison.

The skin in the lower forms can also take the place of lungs. If the lungs of a frog be removed he will continue to live for some time, consume oxygen, and produce carbon dioxide, as in the ordinary mode of breathing, thus showing that respiration can be carried on efficiently by means of the skin.

Having briefly noticed its main anatomical and physiological features, we will now take up the skin comparatively in the five great classes of the vertebrates, and examine its most prominent characters in each.

III. The Classes of Vertebrata.

A. Fishes.

In certain members of this class we find conditions which have undoubtedly been inherited from invertebrate ancestors. Thus in the outer epidermic layer of many Fishes (*Amphioxus*, e.g.) we find a striated border, which can be imagined to consist of coalesced cilia, and in the larval condition we find the free-moving cilia themselves on the outer surface of the epidermis (Fig. 1, S C). Here, as in many other instances, we can see gradual transitions from lower to higher forms.

Glands, such as we find in higher vertebrates, are usually not present in Fishes. The skin secretions which we do find come from single cells or canals (Fig. 1, A). The fluids which they contain probably protect the skin from the action of the water or ward off the attacks of fungoid growth; and it has lately been determined that certain of them function also as sense organs. Other secreting cells are also present, the so-called "*goblet cells*" (Fig. 1, K), whose function has not been definitely determined.

The most marked characteristic of the integument of Fishes is in the scales. These lie in connective-tissue pouches of the derma, and are formed as ossifications of the latter. In the higher types of Fishes they are covered by the epidermis throughout life, but in *Ganoids* (Gar-pikes, etc.) and *Elasmobranchs* (Sharks and Rays) this is only the case in the larva. In the adult they are free and projecting. The primitive form of the common fish scale, as we see it in the Perch, for example, was probably an ossification in the derma, which we call the basal plate with projecting processes, the derm denticles. The transitions which these have undergone from one form to another constitute a very interesting series. In many Fishes, especially fossil, they form a complete protective armor by their fusion, as in the well-known armored South American catfishes.

The next factor to consider is pigment. This always originates in the derma, and to it is due coloration. In endeavoring to account for its presence in the epidermis it has been asserted and observed that white blood corpuscles carry pigment granules to the outer layer, where they take on amœboid movements, and then break up into many small pigment-containing particles,

which are taken up by the epithelial cells. The distribution of pigment over the body varies with the species and individual. It is also subject to changes in environment, and is under direct control of the nervous system. That it changes in order that the animal may adapt itself to its surroundings, has lately been demonstrated in the case of the common English Sole. As is well known, the color of its upper side approximates very closely the tint of the muddy bottom upon which it lives. However, when placed under conditions which permit the access of light to the lower as well as the upper side of its body, pigment will also be developed on that side which formerly showed no trace of it.

We now take up a very important derivation of the integument —*sense organs.* Their main function is probably the perception of mechanical irritations of the surrounding water, but they may also have to do with the perception of sound. As elements we have two kinds of cells : rod-shaped sensory cells, connected by nerve fibres with the central nervous system, and the supporting cells, which lie between the others and serve as connecting and isolating material. The surrounding medium is always kept moist by various secreting cells In those animals which give up an aquatic life in the course of their development and come to live on land, the end organs of the nerves pass further inward, the rod-shaped cells disappear, and we have two kinds of nerve endings in the skin : terminal ganglion cells and free nerve endings. With Fishes we must include Amphibia in the consideration of these sense organs, as the two types are very closely related. "They consist of a central mass of cells, arranged in the form of a rounded and depressed pyramid, and of a peripheral mass grouped around the former. The central cells are in connection with nerve fibres, and each bears on its free end a stiff, cuticular hair ; these are to be looked on as the proper sensory cells, and the others merely as a supporting medium." Where these hairs project freely from the epidermis they are surrounded by a delicate, protective, hyaline tube, which opens into the surrounding water, and into one end the sensory hairs project. These organs are at times distributed over the whole body, but as a rule only in certain well-defined tracts ; those along the sides from the head to the tail form the so-called organs of the lateral line. Others are found in depressions or canals formed by scales, and

then, of course, the protective hyaline tube disappears. Another form of sensory organs are the end bulbs, which in Fishes serve as tactile organs, but in higher forms develop into organs of taste.

B. Amphibia.

The skin of Amphibia, as in the Salamander, exemplifies a transitionary stage from Fishes to Reptiles. Thus, in the aquatic larval forms, two sharply differentiated layers of the epidermis can be made out, the superficial one with that same striated cuticular border which we find in Fishes (Fig. 2, S C). Later, with advancing development, the layers of the epidermis become more numerous, involutions toward the derma take place to form a great number of globular and tube-shaped glands (Fig. 2, X, Y, N). This richness of glands is a marked feature of the skin of Amphibia, and to it they owe their moist and slippery nature. Their secretions serve a variety of purposes, from merely supplying moisture, to a protective function in the form of poison.

Pigment is deposited in great quantities, partly in and partly between the cells of the derma. Here, as in other forms, we see that wonderful adaptation to environment, as exemplified in the well-known green tree-frog and the sandy-colored horned toad of our Western deserts.

Calcifications may also occur in the derma, but they were more abundant in fossil than in modern forms. Some of the integumentary sense organs of this group have already been mentioned in connection with those of Fishes. Another form, which is first met with in the tailless Amphibia (*Anura*), is the tactile spot, consisting of a group of cells in a typical form of papilla, which functions as an organ of touch.

C. Reptiles.

In taking up this group for examination we notice two prominent characters: the formation of scales and other horn-like structures, and the almost total absence of integumentary glands. Scales can here be dismissed with a few words. They are all formed by a change in the epidermis, in which the derma takes part later on. Many widely differing forms all originate in this manner, and can be classed in general with the feathers of birds

and the hair of mammals. The scales and rattles of snakes, the tortoise shell of chelonians, claws, prickles, and warts, are all epidermal.

In this group pigment plays an important rôle. The chameleon is a time-honored and well-known example of the change of color to agree with surroundings. In addition to pigment the formation and structure of the scales in relation to the light-rays may also have something to do with the general effect.

Integumentary sense organs are represented in Snakes, and also in Birds, by tactile cells surrounded by connective-tissue pouches, with septa separating the individual tactile cells and thus forming a tactile corpuscle.

Dermal ossifications were more developed in ancient reptiles than in those of the present day. Crocodiles, some lizards, and principally the chelonia, still maintain dermal structures.

D. Birds.

When we come to examine this group the most characteristic integumentary structures are the feathers, and these will therefore require the greater part of our attention.

Ordinarily feathers appear to be inserted over the entire body of a bird, but on closer view they will be found, with but few exceptions, in certain regions only, called *feather tracts*, separated from each other by naked stretches of skin. These tracts vary in number and position with different genera, as do also the shape and size of the individual feathers. In a general way feathers develop as follows : At the point where one is destined to be formed occurs a slight upheaval of the dermal tissue, followed by the epidermal layer, and thus creating a papilla. As this papilla grows outward and forms a bluntly-pointed cone (Fig. 3, *a*), its base sinks gradually inward ; the epidermis immediately surrounding follows and forms a pocket around the elongated papilla. This papilla is the *feather germ* (Fig. 3, *b*, F), and the pocket constitutes the *feather follicle* (Fig. 3, *b*). The papilla is thus made up of the two layers of the epidermis on the outside, acting as a covering for the mass of dermal cells in the interior, the *pulp* (Fig. 3, *b*).

As the feather germ grows the cells of the inner epidermal or Malpighian layer increase rapidly in number, and grow toward

the centre of the germ in a series of ridges, thus forming folds between them which run the length of the *germ*. Immediately surrounding this is the outer, horny layer of the epidermis (Fig. 3, *c*). Each separate ridge of these internal cells now becomes horn-like, and the central pulp substance dries up. We thus have a bundle of horny rays surrounded by an outer sheath, and of these the pencil-like structures seen on the bodies of newly-hatched birds consist. The outer, horny covering finally breaks off, the rays or barbs become free, and a *down-feather* is formed (Fig. 3, *d*). The lower portion remains in the skin as the *quill*, and the entire structure may remain or be replaced by definite feathers. In such case a second germ forms at the base of the first, the papilla grows rapidly, undergoes nearly the same changes as the other, the embryonic down-feather is pushed out and may often be found attached to one of the barbs of the new feather. At first the two kinds are much alike, but, in the second, one of the rays becomes rapidly thickened and forms a *stem*, to which the barbs are attached on each side, with their *barbules* (Fig. 3, *f*). This theory of feather development, as advanced, with perhaps some slight differences of detail, by Studer (1873) and Kerbert (1876), has been, and is to a great extent even to this day, accepted as the simplest and most probable.

In Birds we have no trace of true dermal bones, and also a marked deficiency in glands, the only ones being the uropygial glands at the base of the tail, whose secretions serve to oil the feathers. Many important epidermal structures, in addition to feathers, are found in this group; such are: claws, spurs, foot scales, and beak sheaths.

E. Mammals.

We now come to the highest class of the vertebrata, and, as in Birds, we will consider first its most prominent feature—namely, hair. Histologically this is quite distinct from the hair-like structures of Birds and Reptiles, which have no true hair. Its development is very interesting.

At the spot where a hair is to be formed an increase in the number of cells of the inner epidermal or Malpighian layer takes place, forming a dome-like mass directed toward the interior (Fig. 4, *a*, *b*, *c*, M). The cells of the derma now arrange them-

selves in mantle form around this mass in a kind of pocket, destined later to become the outer hair sheath. This proliferation of Malpighian cells now assumes a bottle-shaped form, and a differentiation of the constituent cells into central and peripheral portions takes place (Fig. 4, *e*, F, K). The central part consists of elongated cells and grows rapidly outward to form the *hair shaft;* the peripheral layer now becomes a *sheath*. The base of the shaft will now be observed to have assumed a knob-like form; an infolding of its base occurs to contain the nutrient blood vessel (Fig. 4, *e*, *f*, K, B, P). Sebaceous glands for oiling the hair are also produced by proliferations of the Malpighian cells (Fig. 4, *e*, *f*, G). When a shedding of hair takes place a new papilla may be formed at the base of the old one.

Hair plays a very important part in the life history of the Mammalia. It is their most distinguishing characteristic, and here, as much as in any animal type, we can see the great protective value of integumentary derivations, the very nature of the hair mass retaining so large a quantity of the heat of the body.

When pigment is present in Mammals, it occurs in the cells of the Malpighian layer, showing a marked difference from lower forms where it is found principally in the derma.

Epidermic structures are worthy of note in this group. They include many and varied forms: the baleen plates of whales, the spines of the hedgehog and porcupine, the nasal horns of the rhinoceros, the claws of cats and dogs, the bristles of the hog, and many others all belong in this category.

The principal glands are sweat and sebaceous glands. These make up two general classes, the former the simpler, the latter more highly developed histologically. The mammary glands, which characterize this group, can be also looked upon as modified sebaceous glands.

IV. Conclusion.

The five great types of back-boned animals having been examined, it remains for us to consider briefly a few of the relations of the integumentary structures to general organic evolution and to each other.

In the first place, as we have seen, they are divided into two classes: those originating in the derma, in which the epidermis

may or may not take part, and those developing from a purely epidermal source. Fish scales and derm denticles are examples of the former; in the lower types they form a complete exo-skeleton; but as we ascend in the animal scale it is found that as the endo-skeleton becomes more highly developed this exo- or dermal skeleton grows of less and less importance, until finally it disappears altogether. Epidermal structures (hairs, feathers, e.g.) have now become of greater value. It seems that with the higher development of the internal skeleton and the degeneration of dermal structures the epidermal derivatives have grown in importance.

Scales, feathers, and hairs are undoubtedly derived from a more primitive, common condition, for in their individual developments they show many points of resemblance. The intermediate form between reptile-scale and bird-feather has not as yet been found; but feather and hair both point to one antecedent type, found at the present day in the spurs of birds and the hair of Monatremes. For in *Echidna* we find a hair without any medullary substance, and then succeeding stages to typical hair. The spur is very likely descended from a hair with a thickened outer layer. This structure may break up into rays and form a feather, or become flattened out to form a scale.

The relations of these structures to each other have furnished material for many theories, but we still await the final and definite settlement of the question. This is but one of the many problems which constitute such a fascinating field of research to the modern biologist, who can accomplish wonders if he would but attempt to elucidate and harmonize, or else disprove and expunge, some of the many theories of his predecessors regarding these questions.

IN MEMORIAM.

REV. SAMUEL LOCKWOOD, PH.D.

Dr. Lockwood died at his residence, Freehold, N. J., on January 9th, 1894, in the seventy-fifth year of his age.

He was born at Mansfield, England, on January 20th, 1819, and was brought in his infancy to New York City, where he received his education, graduating from the New York University

in 1847. During his university course he accepted the position of assistant editor of the New York *Sun*, offered him by the editor, Mr. Moses Y. Beach. Taking a theological course at the Theological Seminary of the Reformed Dutch Church, at New Brunswick, N. J., he graduated from that institution in 1850; received his ministerial license the same year from the Classis of New York; and immediately entered upon his first pastorate in the Reformed Church at Cortlandtown, Westchester County, N. Y which position he held until 1852. He then filled successive pastorates in Reformed churches, at Gilboa, N. Y., from 1852 to 1854, and at Keyport, N. J., from 1854 to 1869.

In 1867 he was appointed Superintendent of Instruction for Monmouth County, N. J., and for a more central position in this field of labor he moved his residence to Freehold in 1870. It was in this office, which he held until the time of his death, that he rendered service in behalf of public education which will long be remembered for its faithfulness and efficiency.

An interested student of nature from his youngest days, he possessed the enthusiasm, patience, and assiduity which especially succeed in exploring and interpreting the secrets of wonder and beauty veiled from the careless crowd. He took delight in announcing to others what he had learned, as is evidenced by his numerous publications during many years in scientific serials of this and foreign lands, and by his numerous addresses before scientific bodies of our own country.

During his pastorate at Gilboa, Schoharie County, N. Y., he made a special study of the local geology, which resulted in discoveries confirming opinions of the grandeur of the Devonian period, and in a notable palæontological collection, now at Rutgers College, New Jersey. It was of this collection that Prof. George H. Cook, afterward State Geologist of New Jersey, is said to have exclaimed, on displaying it before the students: "If Hugh Miller were living he would want to cross the Atlantic to see it."

At Keyport, N. J., he found a different but no less fascinating field of nature spread out before him, which he enthusiastically cultivated, and in relation to which he issued various noted publications on palæontology and marine zoölogy. It was during this period—1867—that the New York University conferred on him the degree of Doctor of Philosophy.

Dr. Lockwood was an expert microscopist, using his knowledge of the instrument especially in lines of public instruction and benefit. He was one of the founders of the New Jersey State Microscopical Society, and for some years its President. He was elected an Honorary Member of the New York Microscopical Society in 1884, and his interest and zeal in the welfare of this organization are evidenced by his many instructive and valuable addresses, and by his presentation of objects through these years very nearly to the close of his course.

He was possessed of admirable traits of character. Integrity, good-will, and firmness have left him an irreproachable record. His extending knowledge and facile, accurate expression have made him a desired leader and manager of affairs in his lines of duty. Reverence guiding his enthusiastic unfoldings of nature always tended to point the hearer to the Creator. And a kindly disposition, pervaded by a vein of humor, made him a desirable companion. His death will leave a void in the hearts of many acquaintances and friends.

PROCEEDINGS.

Meeting of January 5th, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Annual reports were presented by the Treasurer, Librarian, Recording Secretary, Corresponding Secretary, and the Committee on Publications.

The committee appointed December 15th, 1893, to formulate action on the death of Dr. Paul Hoffman, reported as follows: "Since it has pleased Providence to take from us our friend and fellow-member, Dr. Paul Hoffman, we desire in this manner to express our deep sense of sorrow, and to extend to the bereaved relatives our sympathy."

Mr. Arthur G. Elberg and Dr. Ferdinand G. Kneer were elected Resident Members of the Society.

The President read his Annual Address, entitled "A Microscopical and Chemical Examination of the Admixtures and Adul-

terations in Papers used for Writing and Engraving." This address was illustrated by numerous objects and photomicrographs, as noted below, and is published in this number of the JOURNAL, p. 31.

This being the stated meeting for the annual election of officers, the President appointed Mr. William J. Lloyd and Dr. Anthony Woodward tellers, and at the closing of the polls the following persons were declared elected officers of the Society for 1894:

President, Charles S. Shultz.
Vice-President, Edw. G. Love.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabriskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors { F. W. Devoe. W. E. Damon. F. W. Leggett.

OBJECTS EXHIBITED.

1. *Bacillus tuberculosis*, under a one-quarter-inch objective of his own construction: by F. D. SKEEL.

2. A "Bulloch Stand" made by E. B. Meyrowitz: by F. D. SKEEL.

3. Flax, from a fine example used in spinning at Flatbush, Long Island, in 1821.

4. Linen fibre ready for paper-making.

5. Linen paper extracted from a Michigan Central Railroad bond dated 1872.

6. "Royal Irish Linen" paper containing a large proportion of cotton.

7. Sea Island cotton.

8. The "suspected paper," purported to be linen, but containing linen, cotton, and wood.

9. "Eker" paper from Norway.

10. Sections of wood of *Populus monilifera* Ait.

11. Poplar-wood pulp, "soda process."

12. Sections of spruce wood.

13. Spruce fibre pulped, "sulphite process."

14. "Cottonseed-hull pulp." Proves to be fibre of coniferous wood.

15. Eleven photomicrographs of the above fibres, taken by Dr. Edw. G. Love.

Exhibits Nos. 3–15 by CHARLES S. SHULTZ.

MEETING OF JANUARY 19TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-five persons present.

The following committees were appointed by the Chair:

Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

Committee on Admissions: H. W. Calef, Anthony Woodward, M. M. Le Brun, H. G. Piffard, W. J. Lloyd.

The President announced the death of Rev. Samuel Lockwood, Ph.D., Honorary Member of the Society, and appointed the following committee to formulate suitable action under the circumstances: F. W. Devoe, J. L. Zabriskie, H. G. Piffard.

The Recording Secretary read a letter from Mr. F. W. Devoe referring to the death of Dr. Lockwood, and also an extract from the *Monmouth County Democrat* on the same subject.

Mr. George William Kosmak read a paper entitled "The Comparative Anatomy of the Vertebrate Skin." This paper was illustrated by very fine enlarged colored diagrams, and by objects under microscopes, as noted below, and is published in this issue of the JOURNAL, p. 42.

OBJECTS EXHIBITED.

1. Human blood, eosin stain, under the one-quarter-inch objective exhibited at the last meeting: by FRANK D. SKEEL.

2. Section of leaf of Syrian Wheat, showing trichomes: by FRANK D. SKEEL.

3. Transverse section of skin of Dog-fish with derm denticles projecting.

4. Transverse section of skin of young Sturgeon with derm denticles dropped.

5. Vertical section of *Necturus*, showing glandular developments.

6. Feather germ of Chick at nine days.

7. Vertical section of human scalp, showing roots of hairs.

Exhibits Nos. 3–7 by GEORGE WILLIAM KOSMAK.

Dr. Bashford Dean stated that one of the most important discoveries in this line announced during the past year was that by Miss Julia C. Platt, professor at Mt. Holyoke Seminary, to the effect that the head cartilage is derived from the ectoderm of the embryo.

MEETING OF FEBRUARY 2D, 1894.

The meeting was held in Hamilton Hall, Columbia College. The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons were present.

On motion the routine business of the Society was deferred until the next meeting.

Dr. Alexis A. Julien read a paper entitled "A Silicified Form of a New Species of Fungus in Wood from the Petrified Forest near Cairo, Egypt." This paper was illustrated by numerous excellent photographic lantern views, and by objects under five microscopes, consisting of mineralogical sections, prepared with remarkable carefulness and skill by Mr. T. B. Briggs to exhibit the desired characteristics of the material referred to in the paper.

MEETING OF FEBRUARY 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons present.

On motion it was resolved that the proposed amendment of the By-Laws be laid on the table.

On motion it was resolved that a committee of five be appointed by the Chair to report on amendment of the By-Laws. The following persons were so appointed: Messrs. William G. De Witt, Walter H. Mead, Horace W. Calef, Dr. Frank D. Skeel, Dr. Edw. G. Love.

On motion it was resolved that the above committee be instructed that, if the By-Laws are not explicit on this subject, they

arrange for the plain statement therein that ladies are eligible to resident membership in the Society.

OBJECTS EXHIBITED.

1. Blood of *Amphiuma*, double stained: by FRANK D. SKEEL.

2. Crystals of monobromide of Naphthalin: by CHARLES S. SHULTZ.

MEETING OF MARCH 2D, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Eighteen persons present.

Mr. Francis R. Wardle was elected a Resident Member of the Society.

OBJECTS EXHIBITED.

1. Transverse section of hair of Whale: by CHARLES S. SHULTZ.

2. Transverse section of hair from tail of Elephant: by CHARLES S. SHULTZ.

3. Hair of Horse with eggs and larva of Bot-fly *in situ*: by CHARLES S. SHULTZ.

4. Polyzoon, *Fredericella*, showing statoblasts *in situ*: by HENRY C. BENNETT.

5. Cuticle of *Equisetum*, polarized: by FRANK D. SKEEL.

6. Photomicrographs: Transverse section of stipe of Fern; Transverse section of petiole of Floating Heart, *Limnanthemum*; "Brush and Comb" of Ant; Scale of Eel; "Tongue" of Cricket; Section of Chalcedony; Crystals of Magnesium Sulphate in balsam; Crystals of Morphia Sulphate in balsam.

Dr. Skeel stated, concerning his exhibit, that the Japanese use the stems of *Equisetum* for polishing wood, and also the cuticle of the same, stripped off and inserted in pieces of bamboo, for nail-files, from one of which his specimen was taken.

Dr. Skeel also referred to the late interesting article by Mr. Wenham in the *English Mechanic* on measuring the aperture of lenses, illustrating his remarks by blackboard diagrams.

MEETING OF MARCH 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Messrs. Charles Du Vivier, George R. Du Vivier, and Mrs. Maria O. Le Brun were elected Resident Members of the Society.

The committee appointed with reference to the death of Dr. Samuel Lockwood reported, and the report was accepted and adopted.

Dr. Carlton C. Curtis read a paper entitled "A Contribution to the History of the Formation of the Lichen Thallus." This paper was illustrated by excellent camera drawings, and by objects under microscopes, as noted below.

On motion the thanks of the Society were tendered Dr. Curtis for the paper so presented.

The Corresponding Secretary presented donations to the Cabinet and for distribution among the members from Mr. K. M. Cunningham, of Mobile, Alabama: 1. Chalk, polished, from Waco, Texas, bank of Brazos River; 2. Polished section of limestone from Austin, Texas; 3. Lignite from Mobile Bay, Alabama; 4. Complex crystalline sand from Whistler, Alabama; 5. Green glass slips for examination of the sand; 6. Silicious bodies, designated "*Phytolitharia*."

The donations were accompanied by the following communication from Mr. Cunningham, dated March 13th, 1894:

"I forward to the Society a few specimens illustrating some studies in micro-geology, and which I believe possess some interest microscopically.

"1. A prepared specimen illustrative of a portion of the cretaceous area of Texas. It is an indurated form of chalk found by myself outcropping on the eastern bank of the Brazos River, at Waco, Texas, the stratum underlying the town of Waco.

"Chalk is an earthy carbonate of lime, consisting almost entirely of microscopic shells of foraminifera. There are several special forms of chalk—as the soft, friable, and very white chalk of commerce, derived especially from the celebrated chalk cliffs of England; and, again, as comprised in a very extensive area of the cretaceous belt of the Southern States, notably in Tennessee, Mississippi, and Alabama. I have been deputized by the State Geologist to investigate and report upon the chalk area of the latter State. And the interesting results of an examination of chalk strata from some thirty different points in Alabama, enabled me to record in the State Report on the Cretaceous Rocks

the occurrence of forty species of foraminifera, representing nineteen genera of the foraminifera of the chalk deposits of the globe. These species were identified through the kindness of Anthony Woodward, Ph.D., of New York City. For this purpose I prepared two slides containing, arranged in lines, some one hundred and twenty-five shells each.

"One face of the specimen of Waco chalk is polished in such manner as to exhibit the sections of the various shells and spicular particles, all of which may be seen under a one-quarter-inch lens. By abrading the chalk with a brush while moist, thousands of the perfect crystalline shells may be isolated and studied in their integrity.

"2. A section of limestone, polished on both sides, showing an exceedingly rich aggregation of microscopic Rotaline shells of one species, which in their transverse sections are concave on both faces, similar to the assumed cross-section of a blood corpuscle. This limestone occurs as a stratified formation, and is quarried at Austin, Texas, for the manufacture of lime, and for constructive and monumental purposes.

"3. A specimen of lignite from the shore of Mobile Bay, two miles south of the city, which throws light on the genesis of the coal formations of the carboniferous period. I have already recorded a comprehensive study of this stratum, which will be referred to in the Report on the Tertiary of Alabama.

"The main feature of interest is that when large slabs of the lignite were removed from the water they were as plastic as potter's clay, but they would also readily split into layers, which exhibit the films of ferns and other vegetable impressions. In drying, this lignite shrinks at least fifty per cent in bulk, but preserves the vegetable impressions, which may be readily seen with a low power.

"This small specimen represents the last phase of coal plant deposition, and belongs just under the superficial or pleistocene strata of the tertiary of Alabama. The stratum from which the specimen was derived was heavily impregnated with ferric sulphide, containing myriads of minute golden-hued spherules of pyrite, isolated in quantity by gravity and solution in water.

"4. Packets of a complex crystalline sand derived from the superficial stratum largely capping the argillaceous strata of

Mobile County. A full analytical study of the same has been made for the Alabama Report on the Tertiary.

"The sand has a greater specific gravity than common silicious sands. By the passage of a small magnet, crystalline grains of magnetite and magnetic spherules may be isolated, and when a portion of the sand is spread on a glass slip, and gently tapped to reject all grains which do not adhere, many perfect crystals of silex will be found, showing minute crystalline inclusions, gaseous or other vacuoles, and the characteristic colors of the true gems when examined by polarized light. The use of the green glass slips accompanying these packets differentiates the angles, edges, apices, gaseous vacuoles, and minute crystalline inclusions of these grains, in beautiful pink or rose-colored hues against an emerald-green ground.

"5. A packet of curious silicious bodies, designated by Dr. Ehrenberg as '*Phytolitharia*,' to each of which he gave a specific name in his 'Micro-Geologie,' as if they possessed the same interest as the diatoms and rhizopods usually associated with them.

"These are examined by spreading a thin layer in a dried state under condensed surface illumination, when the characteristic features of each will be noted. If mounted in balsam the stereoscopic character is lost, as all the cylinders, etc., appear flat and of little interest. The differentiating power of the polariscope is well shown on a balsam-mounted slide of these 'Phytolithariæ.' A few scattering grains of silicious sand and micaceous scales respond to the polarizing power, glowing with prismatic colors, but not one of all the various forms of 'Phytolitharia.' These 'Phytolithariæ' are derived from a stratum of swamp clay at Whistler, Alabama, and also from a stratum of bluish plastic clay containing a long series of plant and animal remains, *i.e.*, diatoms, rhizopods, spongilla spicules, plant capsules, and spores in endless profusion."

OBJECTS EXHIBITED.

1. The Alga as scraped from trees: by CARLTON C. CURTIS.

2. Longitudinal section of young thallus: by CARLTON C. CURTIS.

3. Longitudinal section of sporocarp: by CARLTON C. CURTIS.

4. Longitudinal section of apothecium : by CARLTON C. CURTIS.

5. Section of Agate from basalt, Paterson, N. J. : by J. D. HYATT.

6. Section of Pitch Stone, Isle of Arran, Scotland : by J. D. HYATT.

7. Cinnabarite, cinnabar in chalcedony with native gold : by J. D. HYATT.

8. Transverse section of stem of Poison Ivy, *Rhus toxicodendron:* by J. D. HYATT.

9. Sections through head and thorax of House-Fly : by L. RIEDERER.

10. Hemlock joist, 2 × 4 inches × 2 feet, from lintel of door of outbuilding thirty-five years old, almost entirely eaten away by our native large black ant, probably *Camponotus herculaneus* L. : by FRANK D. SKEEL.

Mr. Hyatt explained his exhibit of *Rhus toxicodendron* by means of blackboard drawings, showing that this stem, when growing unattached, has the pith in the centre ; but when attached to a tree or wall, always has an eccentric growth, the pith lying near the bark on the outer side, and the enlarged rings of growth lying on the inner side, next the object of support, thus indicating that nourishment is derived through the rootlets which cling to the support.

THE MICROSCOPE AND MICROSCOPICAL METHODS. Part I. of The Microscope and Histology. By SIMON HENRY GAGE, Associate Professor of Anatomy, Histology, and Embryology in Cornell University. Fifth edition, rewritten, greatly enlarged, and illustrated by 103 figures in the text. Ithaca, N. Y. : Comstock Publishing Co., 1894. Pp. 165. Price, $1.50.

This work had its origin in the necessities of the class room. As stated in the preface, "the aim has been to produce a book for beginners in microscopy, such as the author himself felt sorely the need of when he began the study." How well this object has been accomplished, during the evolution of fifteen years to this present edition, is demonstrated with great satisfaction to

the reader, as he examines the successive chapters with their thorough, clear, and masterly exposition of the necessary successive steps in the knowledge of the microscope and its applications. The book is one of the best of its kind: a labor-saving implement to the beginner, in the class room or out; and to the amateur, who perhaps for years has been feeling his way and attempting in various directions to invent methods of his own, an unspeakable boon in condensing the experience of a host of workers, and bringing this so conveniently at hand where it can be laid hold of at once, as occasion requires. Prof. Gage is to be congratulated on the able manner in which he has improved and augmented the instruction in this volume.

THE BIOLOGY OF FERNS BY THE COLLODION METHOD. By GEORGE F. ATKINSON, Ph.B., Associate Professor of Cryptogamic Botany in Cornell University. Part I.—Descriptive, with 163 illustrations in the text. Part II.—Methods. New York: Macmillan & Co., 1894. Pp. 134. Price, $2.00.

In seven chapters of Part I. of this work the author, in condensed but lucid and satisfactory manner, conducts the reader through the subject of the biology of ferns under two main subdivisions—the gametophytic phase, or the prothallus, with its archegonia, antheridia, and resulting fertilization; and the sporophytic phase, or that of the popularly known fern proper, from embryo through the examination of stem, root, and frond to the fructification, and occasional sporophytic budding, or production of bulbs. In the eighth and concluding chapter of the same part is a short exposition of the structure of the Ophioglosseæ, introduced, as the author says, because they "present excellent subjects for comparative study." Part II. is an exposition of the technique of the collodion method of infiltration and embedding employed in securing the preparations demonstrating and illustrating the successive steps of Part I. The highest commendation of this collodion method is the statement that it has produced the beautiful and accurate illustrations here displayed. The one hundred and sixty-three illustrations are all original, chiefly by the author; but the delicate and encouraging compliment of accrediting each pupil as the preparator and draughtsman, when he has so furnished an occasional illustration, is exceedingly refreshing in these days of ordinarily free-hand appropriation of everything within reach considered as advantageous for the occasion. The paper, presswork, and beautiful figures illustrating the logically arranged and instructive text of this publication combine to render it in every respect most admirable. The work is intended primarily as a text book, a guide, instructor, and incentive in the class room for those who have before them the coveted prize—"Ph.D." But it also gently and invitingly opens the door of access, in view of many an amateur outside the class room, to a department of examination and discovery among the most fascinating in all the domain of botany.

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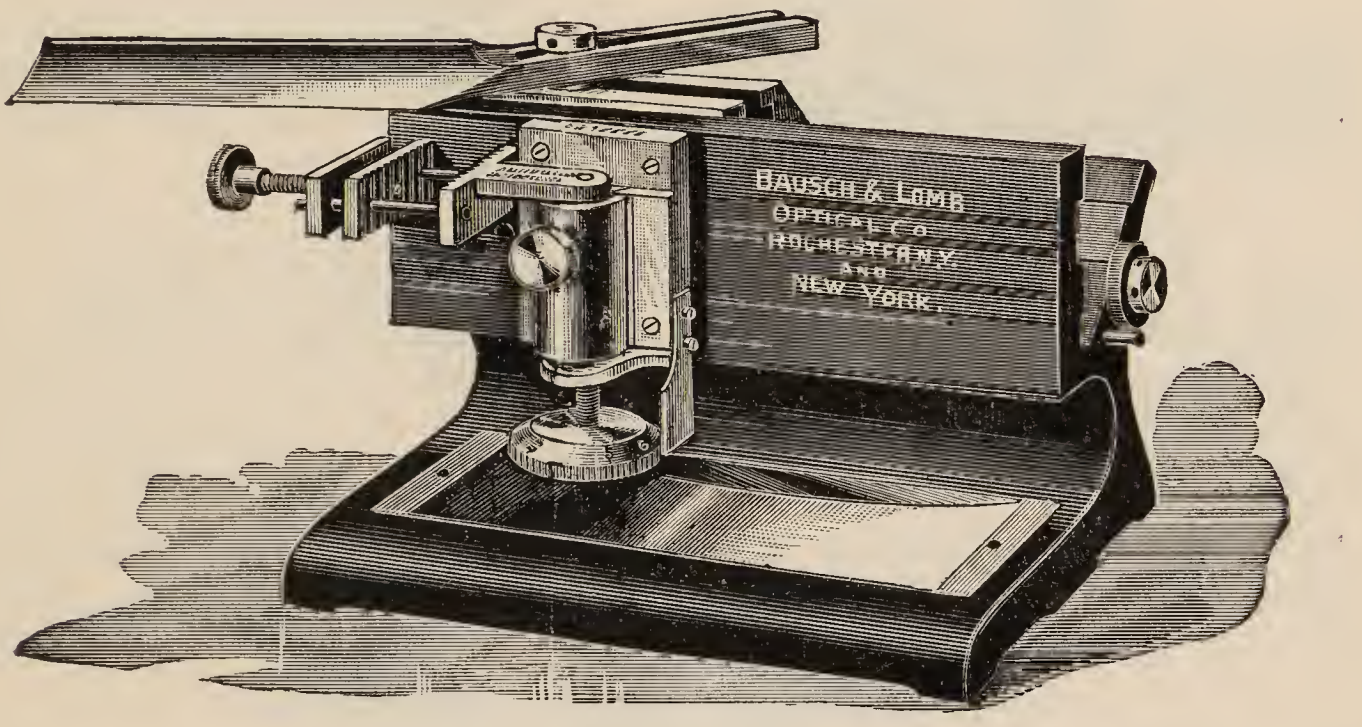

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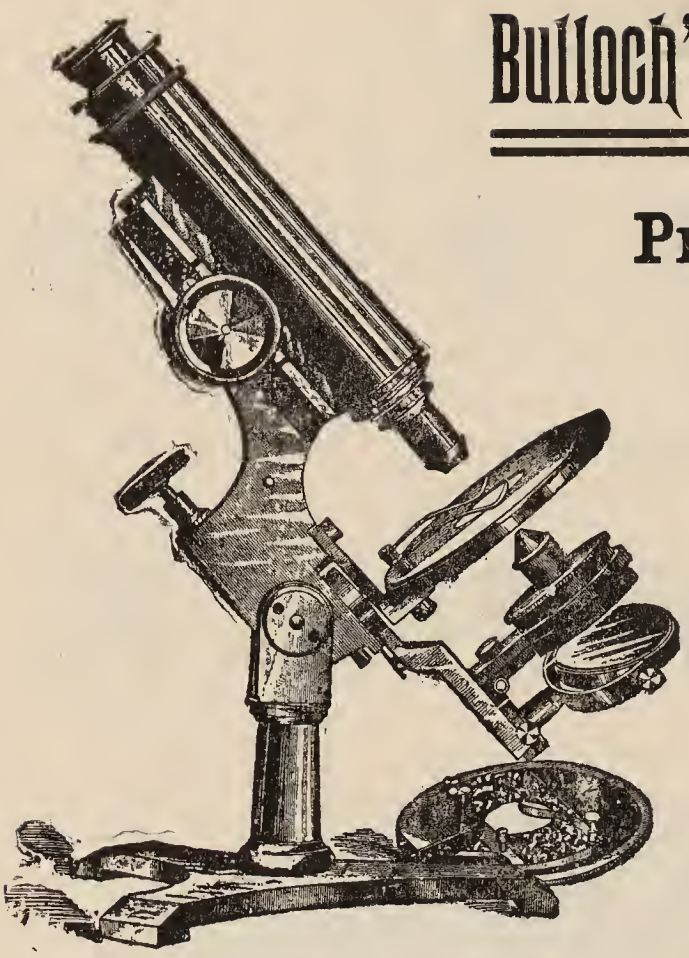

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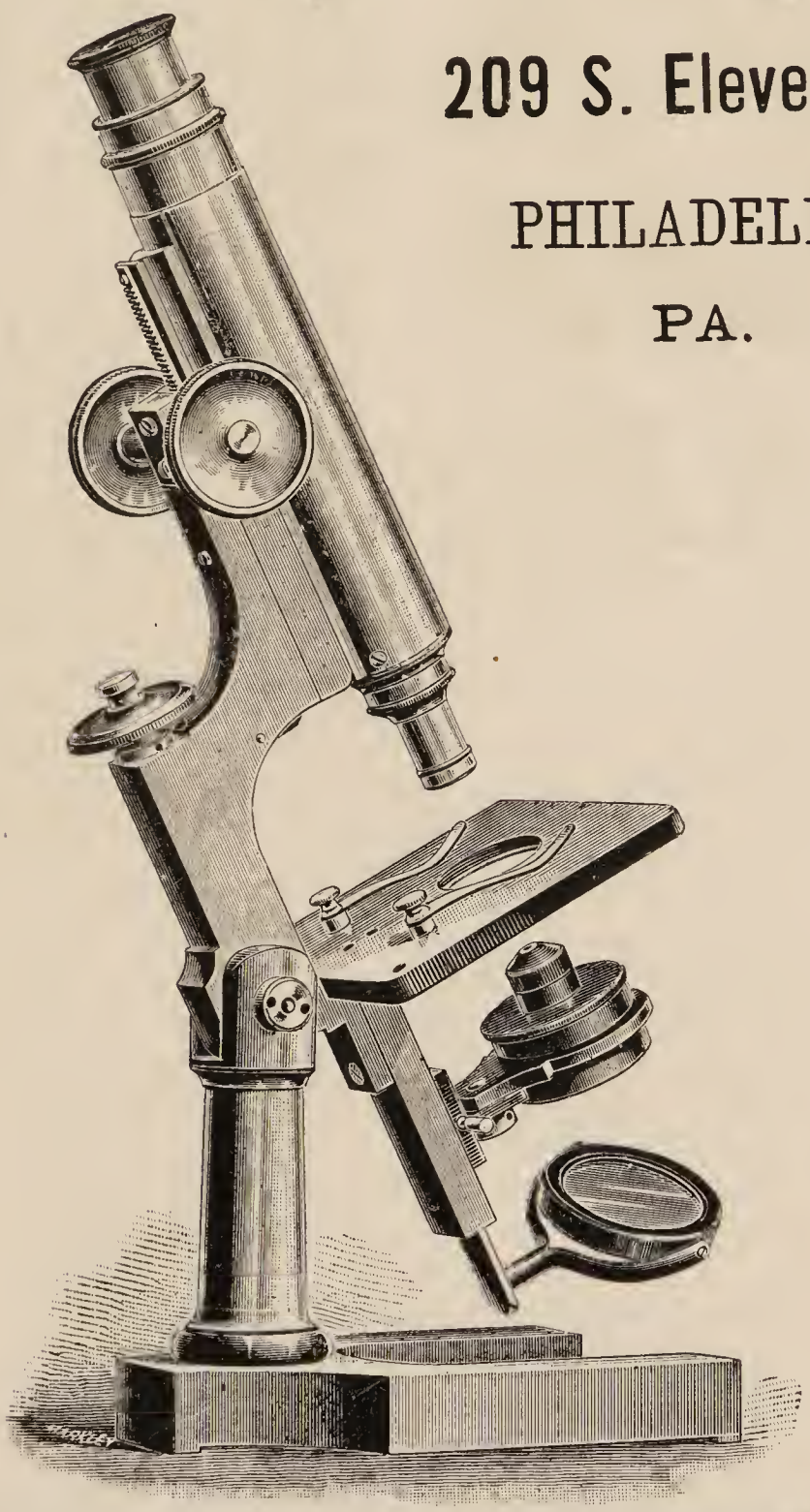

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